NMAM Institute of Technology, Nitte
An off-Campus Institution of
NITTE (Deemed to be University) MANGALORE
B.Tech (Minors) : Scheme of Teaching and Examinations 2022-26
Outcome Based Education (OBE) and Choice Based Credit System (CBCS)
(Effective from the academic year 2022 - 23)

Minors in Electric Vehicles

Sl. No	Course Type	Course Code	Course Title	Teaching Department	Teaching Hours /Week				Examination				Credits
					Lecture	Tutorial	Practical/ Drawing	Self Study/PBL	Duration in hours	CIE Marks	SEE Marks	Total	
					L	T	P	J					
1	PCC	EE2105-1	Introduction to Hybrid Electric Vehicles	EE	3	0	0	0	3	50	50	100	3
2	PCC	EE2106-1	Battery Management Systems	EE	3	0	0	0	3	50	50	100	3
3	PCC	EE3103-1	Thermal Management of Electric Vehicles	EE	3	0	0	0	3	50	50	100	3
4	PCC	EE2107-1	Automotive Electronic Systems	EE	3	0	0	0	3	50	50	100	3
5	PCC	EE3104-1	Vehicle Dynamics	EE	3	0	0	0	3	50	50	100	3
6	PCC	EE3105-1	Fundamental of Automotive Security	EE	3	0	0	0	3	50	50	100	3
				Total	**18**	**0**	**0**	**0**	**18**	**300**	**300**	**600**	**18**

INTRODUCTION TO HYBRID ELECTRIC VEHICLES

Course Code:	**EE2105-1**	**Course Type**	**PCC**
Teaching Hours/Week (L: T: P: S)	**3:0:0:0**	**Credits**	**03**
Total Teaching Hours	**40**	**CIE + SEE Marks**	**50+50**

Teaching Department: Electrical & Electronics Engineering

Course Objectives:

1.	To understand the fundamentals of electric and hybrid electric vehicles, EV policies, standards and EV architecture.
2.	To understand control strategies and design principles of series hybrid vehicle drive train.
3.	To know the design principles & control strategy of parallel and series-parallel hybrid drive train
4.	To study the control principles of plug-in hybrid electric vehicles

UNIT-I

Electric Vehicles	**06 Hours**
Configurations of electric vehicles (EVs), Performance of EVs, Tractive Effort in Normal Driving, Energy Consumption. EV Policies & Standards	
Hybrid Electric Vehicles	**08 Hours**
Concept of Hybrid Electric Drive Trains, Architectures of Hybrid Electric Drive Trains, Series Hybrid Electric Drive Trains, Parallel Hybrid Electric Drive Trains	

UNIT-II

Series (Electrical Coupling) Hybrid Electric Drive Train	**10 Hours**
Operation Patterns, Control Strategies, Design Principles of a Series (Electrical Coupling) Hybrid Drive Train, Design Example	
Parallel (Mechanically Coupled) Hybrid Electric Drive Train	**06 Hours**
Drive Train Configuration and Design Objectives, Control Strategies, Parametric Design of a Drive Train	

UNIT-III

Series–Parallel (Torque and Speed Coupling) Hybrid Drive Train	**05 Hours**
Drive Train Configuration, Drive Train Control Methodology, Drive Train Parameters Design	
Plug-In Hybrid Electric Vehicles	**05 Hours**
Statistics of Daily Driving Distance, Energy Management Strategy, Energy Storage Design.	

Course Outcomes: At the end of the course student will be able to

1.	Describe the fundamentals of electric vehicles to understand EV architecture.
2.	Describe the fundamentals of hybrid electric vehicles to understand EV architecture.
3.	Understand control methodology of series hybrid drive train.
4.	Describe the design principles of parallel hybrid drive train.
5.	Describe the control principles of plug-in hybrid electric vehicles to predict the energy requirements.

Course Outcomes Mapping with Program Outcomes & PSO

Program Outcomes→ ↓ Course Outcomes	1	2	3	4	5	6	7	8	9	10	11	12
EE2105-1.1	3	-	-	-	-	-	-	-	-	-	-	-
EE2105-1.2	2	3	-	-	-	-	-	-	-	-	-	-
EE2105-1.3	2	3	-	-	-	-	-	-	-	-	-	-
EE2105-1.4	2	3	-	-	-	-	-	-	-	-	-	-
EE2105-1.5	3	-	-	-	-	-	-	-	-	-	-	-

1: Low 2: Medium 3: High

TEXTBOOKS:

1. Mehrdad Ehsani, Yimin Gao, Ali Emadi, "Modern Electric, Hybrid Electric, and Fuel Cell Vehicles", CRC Press, 2010.

REFERENCE BOOKS:

1. Tom Denton, "Electric and Hybrid Electric Vehicles", second edition, Institute of motor Industry, 2nd edition, 2020.

E Books / MOOCs/ NPTEL

1. https://nptel.ac.in/courses/108106170

BATTERY MANAGEMENT SYSTEMS

Course Code:	**EE2106-1**	**Course Type:**	**PCC**
Teaching Hours/Week (L: T: P:S):	**3:0:0:0**	**Credits:**	**03**
Total Teaching Hours:	**40+0+0**	**CIE + SEE Marks:**	**50+50**

Teaching Department: Electrical & Electronics Engineering

Course Objectives:

1.	To understand the selection of batteries for Electric vehicle.
2.	To model energy storage system
3.	To familiarize various concepts of BMS
4.	To understand functional blocks of BMS
5.	To study design steps of BMS
6.	To introduce hardware implementation of BMS

UNIT-I

Battery Management System parts	**05 Hours**
The Power Module (PM), The battery, The DC/DC converter, load, communication channel, Examples of Battery Management Systems.	
Basic information on batteries	**06 Hours**
Battery systems, Definitions Battery design, Battery characteristics, General operational mechanism of batteries	
Lithium-Ion Battery Fundamentals	**04 Hours**
Battery Operation, Battery Construction, Battery Chemistry, Safety Longevity, Performance, Integration	

UNIT-II

Measurement of battery parameters	**05 Hours**
Cell Voltage Measurement, Current Measurement, Current Sensors Current Sense Measurements, Synchronization of Current and Voltage, Temperature Measurement, Measurement Uncertainty and Battery Management, System Performance	
Battery Management System Functionality	**03 Hours**
Charging, Strategies, CC/CV Charging Method, Target Voltage Method, Constant Current Method, Thermal Management, Operational Modes	
Charge Balancing	**04 Hours**
Balancing Strategies, Balancing Optimization, Charge Transfer Balancing, Flying Capacitor, Inductive Charge Transfer Balancing, Transformer Charge Balancing, Dissipative Balancing, Balancing Faults	

UNIT-III

State-of-Charge Estimation	**06 Hours**
Challenges, Definitions, Coulomb Counting, SOC Corrections, OCV Measurements, Temperature Compensation, Need of filtering techniques in SoC estimation.	
State-of-Health Estimation	**04 Hours**
State of Health, Mechanisms of Failure, Predictive SOH Models Impedance Detection, Passive Methods, Active Methods.	

Course Outcomes: At the end of the course student will be able to

1.	Review various Battery Management System parts	Explore c
2.	Clarify the basic information about batteries and demonstrate Lithium-Ion Battery Fundamentals	Model an
3.	Measure different battery parameters and analyze battery performance to identify Battery	Identify p

	Management System Functionality	
4.	Detail the need of Charge Balancing and state of charge estimation using various algorithms	Illustrate
5.	Estimate the state of health of the battery and discuss battery fault detection.	Analyze t

Course Outcomes Mapping with Program Outcomes & PSO

Program Outcomes→ ↓ **Course Outcomes**	1	2	3	4	5	6	7	8	9	10	11	12
EE2106-1.1	1	3	-	-	-	-	-	-	-	-	-	-
EE2106-1.2	1	3	-	-	-	-	-	-	-	-	-	-
EE2106-1.3	1	2	3	-	-	-	-	-	-	-	-	-
EE2106-1.4	1	2	2	3	-	-	-	-	-	-	-	-
EE2106-1.5	1	3	-	-	-	-	-	-	-	-	-	-

1: Low 2: Medium 3: High

TEXTBOOKS:

1. H. J. Bergveld, "Battery management systems : design by modelling" University Press Facilities, Eindhoven,2001
2. Phillip Weicker, "A Systems Approach to Lithium-Ion Battery Management", artech house, 2014

REFERENCE BOOKS:

1. Gregory L. Plett, "Battery Management Systems: Battery Modeling", Artech house, 2015
2. M. Barak (Ed.), T. Dickinson, U. Falk, J.L. Sudworth, H.R. Thirsk, F.L. Tye, "Electrochemical Power Sources: Primary & Secondary Batteries", IEE Energy Series 1, A. Wheaton &Co, Exeter, 1980.

THERMAL MANAGEMENT OF ELECTRIC VEHICLES			
Course Code:	**EE3103-1**	**Course Type**	**PCC**
Teaching Hours/Week (L: T: P: S)	**3:0:0:0**	**Credits**	**03**
Total Teaching Hours	**40**	**CIE + SEE Marks**	**50+50**

Teaching Department: Electrical & Electronics Engineering

Course Objectives:

1.	To study semiconductor technology and the importance of thermal management
2.	To understand and derive equivalent thermal resistance network
3.	To explain temperature distribution in the fin and heat transfer rate
4.	To comprehend advanced cooling technologies in electronic equipment
5.	To describe importance and specifications of microelectronics packages

UNIT-I

Introduction to thermal management	**05 Hours**
Semiconductor Technology Trends, Temperature Dependent Electrical Failures, Importance of Heat Transfer in Electronics, Thermal Design Process	
Thermal Resistance Network	**10 Hours**
Thermal Resistance Concept, Series Thermal Layers, Parallel Thermal Layers, General Resistance Network, Thermal Contact Resistance, Interface Materials, Spreading Thermal Resistance, Thermal Resistance of Printed Circuit Boards (PCBs)	

UNIT-II

Fins and Heat Sinks	**07 Hours**
Fin Equation; Fin Thermal Resistance, Effectiveness and Efficiency; Fins with Variable Cross Sections; Heat Sink Thermal Resistance, Effectiveness, and Efficiency; Heat Sink Manufacturing Processes	
Advanced Cooling Technologies	**08 Hours**
Heat Pipes- Capillary Limit, Boiling Limit, Sonic Limit, Entrainment Limit, Other Heat Pipe Performance Limits, Heat Pipe Applications in Electronic Cooling, Heat Pipe Selection and Modeling, Thermosyphons, Liquid Cooling	

UNIT-III

Thermal Specification of Microelectronic Packages	**10 Hours**
Importance of Packaging, Packaging Types, Specifications of Microelectronic Packages- Junction-to-Air Thermal Resistance, Junction-to-Case and Junction-to-Board Thermal Resistances, Parameters Affecting Thermal Characteristics of a Package	

Course Outcomes: At the end of the course student will be able to

1.	Understand the possible failures and the importance of efficient heat transfer techniques to modify the design to cool a system
2.	Develop equivalent thermal resistance network to calculate the heat transfer rate
3.	Compute temperature distribution in the fin and heat transfer rate to reduce heat dissipation
4.	Describe the different techniques used for cooling electronic equipment
5.	Calculate thermal resistance of different electronic packages to calculate maximum allowable junction temperature

Course Outcomes Mapping with Program Outcomes & PSO

Program Outcomes→ ↓ Course Outcomes	1	2	3	4	5	6	7	8	9	10	11	12
EE3103-1.1	3	2	-	-	-	-	-	-	-	-	-	-
EE3103-1.2	3	2	-	-	-	-	-	-	-	-	-	-
EE3103-1.3	3	2	-	-	-	-	-	-	-	-	-	-
EE3103-1.4	3	2	-	-	-	-	-	-	-	-	-	-
EE3103-1.5	3	2	-	-	-	-	-	-	-	-	-	-

1: Low 2: Medium 3: High

TEXTBOOKS:

1. Younes Shabany,"Heat Transfer: Thermal Management of Electronics" 2010 , CRC Press.

REFERENCE BOOKS:

1. Jerry Sergent, Al Krum, "Thermal Management Handbook: For Electronic Assemblies Hardcover", 1998, Mc Graw- Hill.
2. "Vehicle thermal Management Systems Conference Proceedings", 1st Edition; 2013, Coventry Techno centre, UK
3. T. Yomi Obidi, "Thermal Management in Automotive applications", 2015, SAE International.

AUTOMOTIVE ELECTRONIC SYSTEMS

Course Code:	**EE2107-1**	**Course Type**	**PCC**
Teaching Hours/Week (L: T: P: S)	**3:0:0:0**	**Credits**	**03**
Total Teaching Hours	**40+0+0**	**CIE + SEE Marks**	**50+50**

Teaching Department: Electrical & Electronics Engineering

Course Objectives:

1. Understand various aspects of electronic system in vehicle control
2. Familiarized with various sensors used in vehicle control.
3. Comprehend the communication protocol used in vehicle.
4. Understand concepts of AUTOSAR.
5. Know the data processing and memory management system

UNIT-I

Electrical and Electronic Systems in the Vehicle — **07 Hours**

Overview, Motoronic-engine management system, Electronic diesel control, Lighting technology, electronic stability program, adaptive cruise control, Infotainment System.

Automotive Sensors & Measuring Principle — **08 Hours**

Air Flow Rate Sensor, Engine Crankshaft Angular Position Sensor, Magnetic Reluctance Position Sensor, Hall-Effect Position Sensor, Optical Crankshaft Position Sensor, Throttle Angle Sensor, Temperature Sensors, Exhaust Gas Oxygen Sensor, Knock Sensors, Automotive Engine Control Actuators.

UNIT-II

In Vehicle Networking — **07 Hours**

Need for In-vehicle Networking, Vehicle buses. Overview of CAN, LIN, Flex Ray, MOST protocols. Vehicular ad hoc networks (VANETs).

AUTOSAR Concepts — **08 Hours**

Architecture, Methodology and Application Interfaces. ECU SW Architecture, Virtual Function Bus, Abstraction Layer, BSW, RTE, ECU Communication.

UNIT-III

Architecture of Electronic Systems & Control Units — **10 Hours**

Basics and Overview, vehicle system architecture. Control units, Operating conditions, Design and data processing. Digital modules in the control unit. Automotive Applications.

Course Outcomes: At the end of the course student will be able to

1. Describe the function and operation of Automotive Electrical and Electronic subsystems.
2. Discus the principle and operation of sensors and actuators used in automotive applications.
3. Analyse the use of CAN, LIN, MOST and Flexray protocols in automotive applications.
4. Explain the architecture & Methodology of AUTOSAR.
5. Describe automotive data processing and memory system

Course Outcomes Mapping with Program Outcomes & PSO

Program Outcomes→ / ↓ Course Outcomes	1	2	3	4	5	6	7	8	9	10	11	12
EE2107-1.1	2	-	-	-	-	-	-	-	-	-	-	1
EE2107-1.2	2	1	1	-	-	-	-	-	3	3	1	1
EE2107-1.3	1	1	1	-	-	-	-	-	3	3	1	1
EE2107-1.4	1	-	-	-	-	-	-	-	-	1	-	1
EE2107-1.5	2	-	1	-	-	-	-	-	3	3	1	1

1: Low 2: Medium 3: High

TEXTBOOKS:	
1.	Robert Bosch GmbH, "Bosch Automotive Electrics and Automotive Electronics", 5th Edition. John Wiley & Sons Ltd, 2007
2.	William B. Ribbens "Understanding Automotive Electronics", 6th Edition, Elsevier, 2003
3.	Tom Denton, "Automobile Electrical and Electronic Systems", 3rd Edition, Elsevier Butterworth-Heinemann Publication, 2004.
4.	KPIT Technologies Ltd. "KPIT-AUTOSAR Handbook", https://www.kpit.com/resources/downloads/kpit-autosar-handbook.pdf
REFERENCE BOOKS:	
1.	Nicolas Navet and Françoise Simonot-Lion, "Automotive Embedded Systems Handbook", CRC Press, 2009.

VEHICLE DYNAMICS

Course Code:	**EE3104-1**	**Course Type**	**PCC**
Teaching Hours/Week (L: T: P: S)	**3:0:0:0**	**Credits**	**03**
Total Teaching Hours	**40+0+0**	**CIE + SEE Marks**	**50+50**

Teaching Department: Electrical & Electronics Engineering

Course Objectives:

1.	Understand the dynamics of vehicle ride under different riding condition.
2.	Present a problem oriented in depth knowledge of Vehicle Dynamics.
3.	Address the underlying concepts and methods behind Vehicle Dynamics
4.	Calculate and refer the loads and forces associated to the vehicles.
5.	Analyse the behaviour of the vehicles under acceleration, ride and braking

UNIT-I

Basics of Vehicle Dynamics — **07 Hours**

History, vehicle classifications, fundamental approaches to vehicle dynamics modelling; SAE Vehicle axis system, Forces & moments affecting vehicle, Earth Fixed coordinate system, Dynamic axle loads, Equations of motion, transmission characteristics, vehicle performance.

Acceleration Performance: — **08 Hours**

Power train components; power and traction limited acceleration; transverse weight shift; front wheel drive vs rear wheel drive vs. all-wheel drive vehicles

UNIT-II

Braking Performance: — **10 Hours**

Braking force analysis; brake design and analysis; federal regulation on braking performance; antilock braking system; wheel lock-up; tire/road friction; safety and maintenance issues in braking, Brake proportioning, Braking efficiency

Road Loads — **04 Hours**

Aerodynamics, rolling resistance; breakdowns of total road loads.

UNIT-III

Tire and Tire Dynamics — **05 Hours**

Tire specifications and constructions; tire motion analysis; tire force analysis; tire contact stress analysis; tire vibration analysis; tire models

Ride — **05 Hours**

Excitation Sources, Vehicle response properties, perception of ride

Course Outcomes: At the end of the course student will be able to

1.	Analyse the dynamics of vehicle under different riding condition.
2.	Analyse acceleration performance of vehicle under dynamic conditions.
3.	Analyse braking performance in vehicle under dynamic conditions.
4.	Articulate road loads and tyre dynamics in vehicles.
5.	Interpret tire dynamic and ride comfort for better understand the vehicle performance.

Course Outcomes Mapping with Program Outcomes & PSO

Program Outcomes→ / ↓ Course Outcomes	1	2	3	4	5	6	7	8	9	10	11	12
EE3104-1.1	2	-	2	-	2	-	-	-	-	-	-	-
EE3104-1.2	2	-	2	-	2	-	-	-	-	-	-	-
EE3104-1.3		-	2	1	-	-	-	-	-	-	-	-
EE3104-1.4	2	-	2	-	-	-	-	-	-	-	-	-
EE3104-1.5	2	-	2	-	-	-	-	-	-	-	-	-

1: Low 2: Medium 3: High

REFERENCE BOOKS:

1. Fundamentals of Vehicle Dynamics, Thomas Gillespie, SAE Publication.
2. The Multibody systems Approach to Vehicle Dynamics, Mike Blundell and Damian Harty, Elsevier, 2004.
3. Vehicle Dynamics, Theory and Application, Reza N. Jazar, Springer, 2009, ISBN 978-0-387-74243-4, e-ISBN 978-0-387-74244.
4. Race Car Vehicle Dynamics, W.F. Milliken and D.L. Milliken, SAE, 1995, ISBN 1-56091-526-9.
5. Reimpell, Stoll and Betzler: The Automotive Chassis: Engineering Principles. Butterworth-Heinemann Publisher, 2nd Edition, 2001
6. Hans Pacejka, Tire and Vehicle Dynamics, Elsevier, 2012
7. Rajesh Rajamani, Vehicle Dynamics & control, Springer, 2014
8. R.V. Dukkipati, Vehicle dynamics, Narova Publications, 2000.

FUNDAMENTALS OF AUTOMOTIVE SECURITY

Course Code:	**EE3105-1**	**Course Type:**	**PCC**
Teaching Hours/Week (L: T: P:S):	**3:0:0:0**	**Credits:**	**03**
Total Teaching Hours:	**40+0+0**	**CIE + SEE Marks:**	**50+50**

Teaching Department: Electrical & Electronics Engineering

Course Objectives:

1.	To understand the methods of cryptography
2.	To know the importance of embedded security
3.	To understand the network security issues in automotive network
4.	To understand the requirement of firmware resiliency in automotive application.

UNIT-I

Introduction to Cryptography	**14 Hours**

Introduction to cryptography, Classical Cryptosystem, message authentication, hash functions, public key encryptions, user authentications

Block Cipher Data Encryption Standard (DES), Triple DES, Modes of Operation, Stream Cipher. Advanced Encryption Standard (AES), Introduction to Public Key Cryptosystem, Diffie-Hellman Key Exchange, Knapsack Cryptosystem, RSA Cryptosystem.

UNIT-II

Protecting IP in cloud connected world	**08 Hours**

Protection of IP, CODE isolation, encryption, hardware security, trustonic expertise tool for IP protection.

Embedded Security: Introduction	**08 Hours**

Authentication, Integrity and Confidentiality, Properties of secure system Security elements(JIL), importance of keys in security, customization challenges, distribution of keys, tools and examples.(cryptoAuthlib)

UNIT-III

Automotive Network security	**10 Hours**

Motivation for automotive network security, Automotive security, message authentication, Automotive security IC attributes, security challenges.

Firmware Resiliency in Automotive application

Course Outcomes: At the end of the course student will be able to

1.	Describe the principles of data encryptions in cryptography
2.	Comprehend the algorithms of cryptography for data security
3.	Explain the importance of Protection of IP in cloud connected network
4.	Analyze the importance of key security and customization challenges for embedded security
5.	Describe the importance of message authentication and security challenges and solutions for automotive network.

Course Outcomes Mapping with Program Outcomes & PSO

Program Outcomes→ **↓ Course Outcomes**	1	2	3	4	5	6	7	8	9	10	11	12
EE3105-1.1	3	2	-	-	-	-	-	-	-	-	-	-
EE3105-1.2	3	2	-	-	-	-	-	-	-	-	-	-
EE3105-1.3	3	2	-	-	-	-	-	-	-	-	-	-
EE3105-1.4	3	2	-	-	-	-	-	-	-	-	-	-
EE3105-1.5	3	2	-	-	-	-	-	-	-	-	-	-

1: Low 2: Medium 3: High

TEXTBOOKS:

1. Wiiliam Stallings, "Cryptography and Network security Principles and practices ", 4th Edition, prentice hall, November 16,2015.